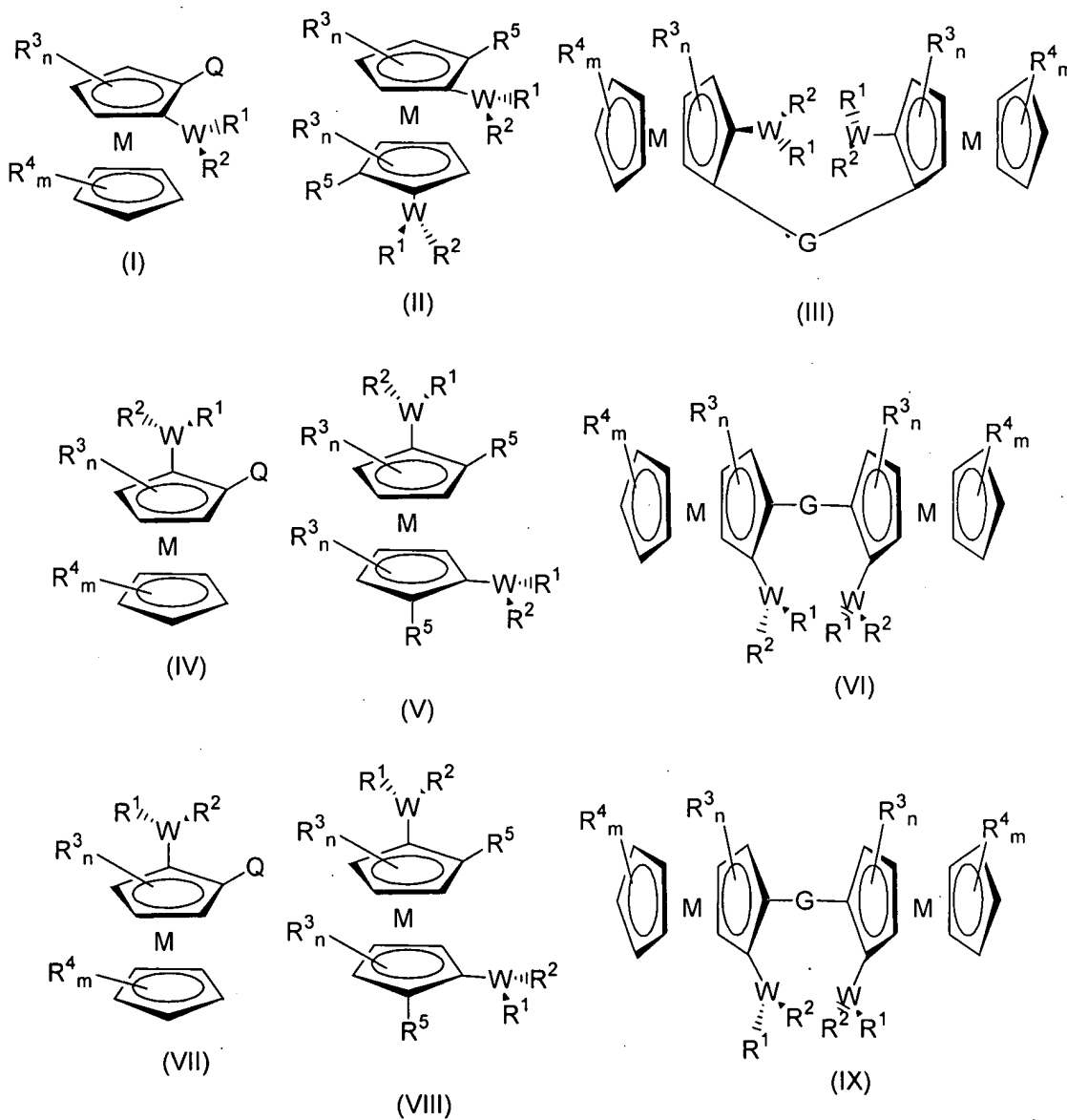


## Amendments to the Claims

1-43. (Cancelled)

44. (New) A metallocene-based ligand having a formula selected from the group consisting of Formula (I), Formula (II), Formula (III), Formula (IV), Formula (V), Formula (VI), Formula (VII), Formula (VIII), and Formula (IX):



wherein

W is phosphorus or arsenic;

M is a metal;

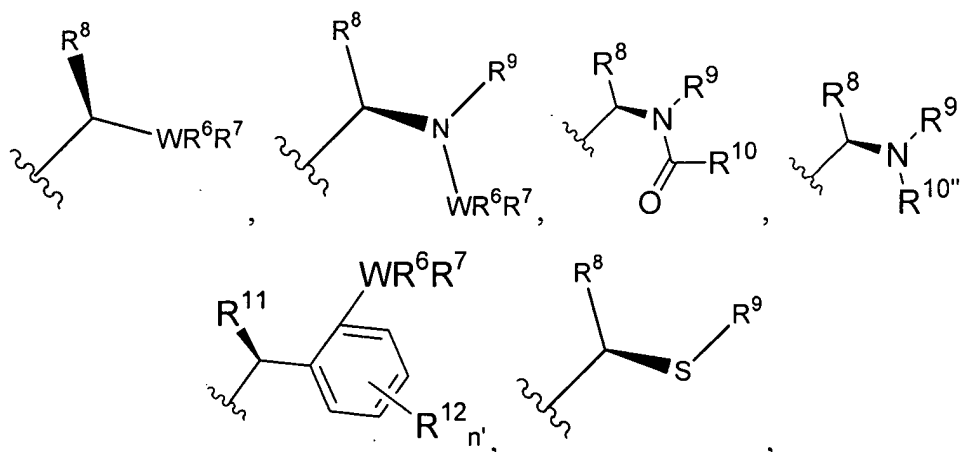
$R^1$  and  $R^2$  are different from each other and are independently selected from the group consisting of unsubstituted branched-chain alkyl, unsubstituted straight-chain alkyl, unsubstituted alkoxy, unsubstituted alkylamino, unsubstituted cycloalkyl, unsubstituted cycloalkoxy, unsubstituted cycloalkylamino, unsubstituted carbocyclic aryl, unsubstituted carbocyclic aryloxy, unsubstituted heteroaryl, unsubstituted heteroaryloxy, unsubstituted carbocyclic arylamino, unsubstituted heteroarylamino, substituted branched-chain alkyl, substituted straight-chain alkyl, substituted alkoxy, substituted alkylamino, substituted cycloalkyl, substituted cycloalkoxy, substituted cycloalkylamino, substituted carbocyclic aryl, unsubstituted carbocyclic aryloxy, substituted heteroaryl, substituted heteroaryloxy, substituted carbocyclic arylamino, and substituted heteroarylamino;

$R^3$  and  $R^4$  are independently selected from the group consisting of substituted branched-chain alkyl, substituted straight-chain alkyl, substituted cycloalkyl, substituted carbocyclic aryl, substituted heteroaryl, unsubstituted branched-chain alkyl, unsubstituted straight-chain alkyl, unsubstituted cycloalkyl, unsubstituted carbocyclic aryl, and unsubstituted heteroaryl;

n is an integer from 0 to 3;

m is an integer from 0 to 5;

Q is selected from the group consisting of



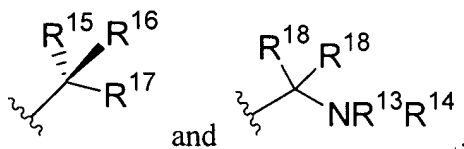
wherein

$R^6$  and  $R^7$  are independently selected from the group consisting of substituted branched-chain alkyl, substituted straight-chain alkyl, substituted alkoxy, substituted alkylamino, substituted cycloalkyl, substituted cycloalkoxy, substituted cycloalkylamino, substituted carbocyclic aryl, substituted carbocyclic aryloxy, substituted heteroaryl, substituted heteroaryloxy, substituted carbocyclic arylamino, substituted heteroarylamino, unsubstituted branched-chain alkyl, unsubstituted straight-chain alkyl, unsubstituted alkoxy, unsubstituted alkylamino, unsubstituted cycloalkyl, unsubstituted cycloalkoxy, unsubstituted cycloalkylamino, unsubstituted carbocyclic aryl, unsubstituted carbocyclic aryloxy, unsubstituted heteroaryl, unsubstituted heteroaryloxy, unsubstituted carbocyclic arylamino, and unsubstituted heteroarylamino;

$R^8$ ,  $R^9$ ,  $R^{10}$  and  $R^{10''}$  are independently selected from the group consisting of hydrogen, substituted straight-chain alkyl, unsubstituted straight-chain alkyl, substituted branched-chain alkyl, unsubstituted branched-chain alkyl, substituted cycloalkyl, unsubstituted cycloalkyl, substituted carbocyclic aryl, unsubstituted carbocyclic aryl, substituted heteroaryl, and unsubstituted heteroaryl;  $R^{11}$  is selected from the group consisting of  $OR^{13}$ ,  $SR^{13}$ ,  $NHR^{13}$ , and  $NR^{13}R^{14}$ , wherein

$R^{13}$  and  $R^{14}$  are independently selected from the group consisting substituted branched-chain alkyl, unsubstituted branched-chain alkyl, substituted cycloalkyl, unsubstituted cycloalkyl, substituted carbocyclic aryl, unsubstituted carbocyclic aryl, substituted heteroaryl, and unsubstituted heteroaryl;  $R^{12}$  is selected from the group consisting of hydrogen, halogen,  $OR^{13}$ ,  $SR^{13}$ ,  $NR^{13}R^{14}$ , substituted branched-chain alkyl, unsubstituted branched-chain alkyl, substituted cycloalkyl, unsubstituted cycloalkyl, substituted carbocyclic aryl, unsubstituted carbocyclic aryl, substituted heteroaryl, and unsubstituted heteroaryl, and  $n'$  is 0 to 4;

$R^5$  is selected from:

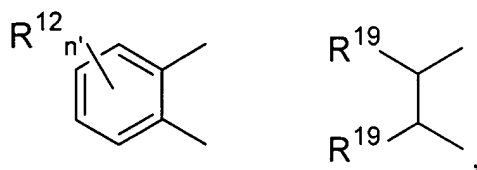


wherein  $R^{15}$ ,  $R^{16}$  and  $R^{17}$  are independently selected from the group consisting of hydrogen, halogen,  $OR^{13}$ ,  $SR^{13}$ ,  $NR^{13}R^{14}$ , substituted branched-chain alkyl, unsubstituted branched-chain alkyl, substituted cycloalkyl, unsubstituted cycloalkyl substituted carbocyclic aryl, unsubstituted carbocyclic aryl, substituted heteroaryl, and unsubstituted heteroaryl; and wherein the two

geminal substituents  $R^{18}$  together are a doubly bonded oxygen atom, or each substituent  $R^{18}$  is individually hydrogen; and G is selected from the group consisting of  $-C(=O)NH-R^*-NHCO-$ ,  $-C(=O)-OR^*O-C(=O)-$ ,  $-C(=O)-R^*C(=O)-$ ,  $-CH=N-R^*-N=CH-$ ,  $-CH_2NH-R^*-NHCH_2-$ ,  $-CH_2NHC(=O)-R^*-C(=O)NHCH_2-$ ,  $-CH(R^8)NH-R^*-NH(CH(R^8)-$ ,  $-CH(R^8)NHC(=O)-R^*-C(=O)NHCH(R^8)-$ ,  $-C(=O)NH-R-NHC(=O)-$ ,  $-C(=O)-ORO-C(=O)-$ ,  $-C(=O)-RC(=O)-$ ,  $-CH=N-R-N=CH-$ ,  $-CH_2NH-R-NHCH_2-$ ,  $-CH_2NHC(=O)-R-C(=O)NHCH_2-$ ,  $-CH(R^8)NH-R-NH(CH(R^8)-$ ,  $-CH(R^8)NHC(=O)-R-C(=O)NHCH(R^8)-$ ;

wherein  $R^8$  is, independently, as previously defined;

$-R^*$ - and  $-R-$  are selected from the group consisting of:



wherein  $R^{12}$  is as previously defined;

wherein the two substituents  $R^{19}$  together are  $-(CH_2)_m-$  or each substituent  $R^{18}$  is independently selected from the group consisting of hydrogen, substituted branched-chain alkyl, unsubstituted branched-chain alkyl, substituted cycloalkyl, unsubstituted cycloalkyl, substituted carbocyclic aryl, unsubstituted carbocyclic aryl, substituted heteroaryl, and unsubstituted heteroaryl; wherein the or each heteroatom is independently selected from sulphur, nitrogen,  $n'$  is an integer of from 0 to 4; and  $m'$  is an integer of from 1 to 8;

with the proviso that for compounds of formula (I), whereby  $n$  and  $m$  is an integer of 0, the substitution pattern for  $R^1$  and  $R^2$  does not include the pairings of:

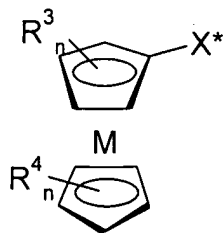
phenyl - methyl, phenyl - n-butyl, phenyl - tert-butyl, phenyl - 3,5-bis(trifluoromethyl)phenyl, phenyl - anthracenyl, and n-butyl - tert-butyl.

45. (New) The metallocene-based ligand of Claim 44, which is a diastereomer having Formula (IV), Formula (V), or Formula (VI).

46. (New) The metallocene-based ligand of Claim 44, which is an enantiomer having Formula (VII), Formula (VIII), or Formula (IX).
47. (New) The metallocene-based ligand of Claim 44, wherein the metallocene-based ligand is a phosphine or arsine having chirality at W, and wherein the metallocene-based ligand has at least one additional element of chirality selected from the group consisting of chirality at carbon, and axial chirality.
48. (New) The metallocene-based ligand of Claim 44, wherein the metallocene-based ligand is a diphosphine or diarsine having chirality at W, and wherein the metallocene-based ligand has two additional elements of chirality comprising chirality at carbon, and axial chirality.
49. (New) The metallocene-based ligand of Claim 44, wherein the metallocene is ferrocene.
50. (New) The metallocene-based ligand of Claim 1, wherein W is phosphorus.
51. (New) A catalyst or catalyst precursor in an asymmetric transformation reaction to generate a high enantiomeric excess of a formed compound, the catalyst or catalyst precursor comprising the metallocene-based ligand of Claim 44.
52. (New) A transition metal complex containing a transition metal coordinated to a ligand according to the metallocene-based ligand of Claim 44.
53. (New) A transition metal complex according to Claim 52, wherein the transition metal is a Group VIb or a Group VIII metal.

54. (New) A method for preparing the metallocene-based ligand of Claim 44, comprising:  
 providing a metallocene-based substrate having a chiral directing substituent on one or both rings;  
 ortho-lithiating the metallocene-based substrate; and  
 converting the ortho-lithiated metallocene-based substrate to obtain the metallocene-based ligand.

55. (New) The method according to Claim 54, wherein the metallocene-based ligand has Formula (I) or Formula (III), wherein the metallocene-based substrate has Formula (X'):



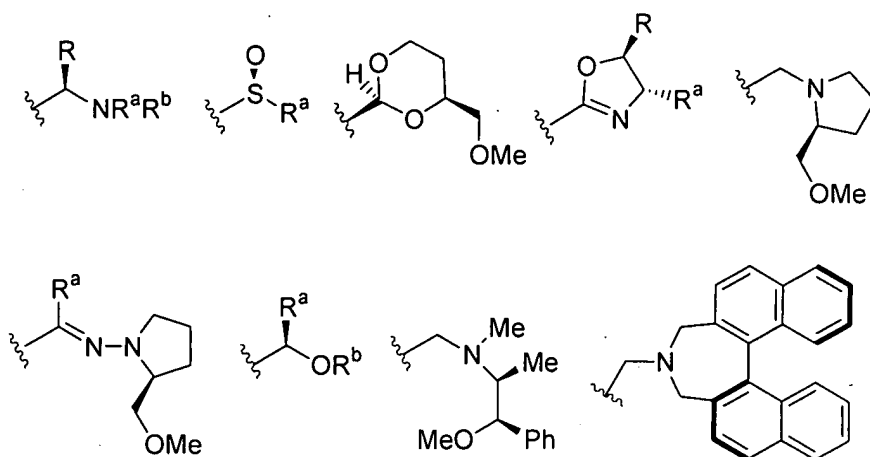
Formula (X') ,

wherein  $R^3$  and  $R^4$  are independently selected from the group consisting of substituted branched-chain alkyl, substituted straight-chain alkyl, substituted cycloalkyl, substituted carbocyclic aryl, substituted heteroaryl, unsubstituted branched-chain alkyl, unsubstituted straight-chain alkyl, unsubstituted cycloalkyl, unsubstituted carbocyclic aryl, and unsubstituted heteroaryl;

$n$  is an integer from 0 to 3;

and wherein  $X^*$  is a chiral directing group, wherein the step of converting the ortho-lithiated metallocene-based substrate comprises reacting the ortho-lithiated substrate with an  $R^1$  substituted phosphine or arsine, and with an  $R^2$ -bearing Grignard reagent or an  $R^2$ -organolithium compound, then converting  $X^*$  to  $Q$  or  $G$ .

56. (New) A method according to Claim 55, wherein  $X^*$  is selected from the group consisting of:



wherein

$R^a$  and  $R^b$  are independently selected from the group consisting of substituted branched-chain alkyl, substituted straight-chain alkyl, substituted cycloalkyl, substituted carbocyclic aryl, substituted heteroaryl, unsubstituted branched-chain alkyl, unsubstituted straight-chain alkyl, unsubstituted cycloalkyl, unsubstituted carbocyclic aryl, and unsubstituted heteroaryl.

57. (New) The method according to Claim 55, wherein the ortho-lithiation step is conducted using at least one lithiating agent selected from the group consisting of n-butyllithium, sec-butyllithium, and tert-butyllithium.

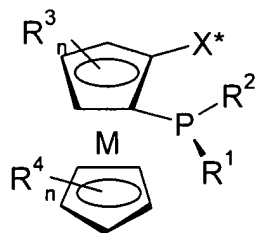
58. (New) The method according to Claim 57, wherein the step of converting the ortho-lithiated metallocene-based substrate comprises reacting the ortho-lithiated metallocene-based substrate *in situ* with a dichlorophosphine of the formula  $R^1PCl_2$  wherein  $R^1$  is selected from the group consisting of unsubstituted branched-chain alkyl, unsubstituted straight-chain alkyl, unsubstituted alkoxy, unsubstituted alkylamino, unsubstituted cycloalkyl, unsubstituted cycloalkoxy, unsubstituted cycloalkylamino, unsubstituted carbocyclic aryl, unsubstituted carbocyclic aryloxy, unsubstituted heteroaryl, unsubstituted heteroaryloxy, unsubstituted carbocyclic arylamino, unsubstituted heteroarylamino, substituted branched-chain alkyl, substituted straight-chain alkyl, substituted alkoxy, substituted alkylamino, substituted cycloalkyl, substituted cycloalkoxy, substituted cycloalkylamino, substituted carbocyclic aryl,

substituted carbocyclic aryloxy, substituted heteroaryl, substituted heteroaryloxy, substituted carbocyclic arylamino, and substituted heteroarylamino;

to yield an intermediate product, wherein the intermediate product is converted to obtain the metallocene-based ligand.

59. (New) The method according to Claim 58, further comprising reacting the intermediate product with an organometallic reagent of formula  $R^2Z$ , wherein  $R^2$  is selected from the group consisting of unsubstituted branched-chain alkyl, unsubstituted straight-chain alkyl, unsubstituted alkoxy, unsubstituted alkylamino, unsubstituted cycloalkyl, unsubstituted cycloalkoxy, unsubstituted cycloalkylamino, unsubstituted carbocyclic aryl, unsubstituted carbocyclic aryloxy, unsubstituted heteroaryl, unsubstituted heteroaryloxy, unsubstituted carbocyclic arylamino, unsubstituted heteroarylamino, substituted branched-chain alkyl, substituted straight-chain alkyl, substituted alkoxy, substituted alkylamino, substituted cycloalkyl, substituted cycloalkoxy, substituted cycloalkylamino, substituted carbocyclic aryl, substituted carbocyclic aryloxy, substituted heteroaryl, substituted heteroaryloxy, substituted carbocyclic arylamino, and substituted heteroarylamino;

wherein Z is Li or MgY, and wherein Y is a halide, to obtain a phosphorus chiral compound having formula (XI'):



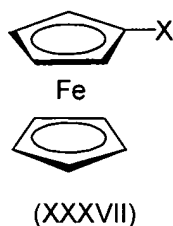
Formula (XI')

wherein the phosphorous chiral compound is converted to obtain the metallocene-based ligand.

60. (New) The method of Claim 59, wherein the metallocene-based ligand has Formula (I) or Formula (III).



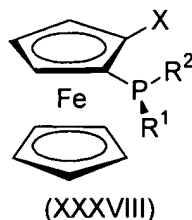
61. (New) A method for preparing a metallocene-based ligand of Claim 44, comprising:  
providing a compound of Formula (XXXVII):



wherein X is an achiral directing group;

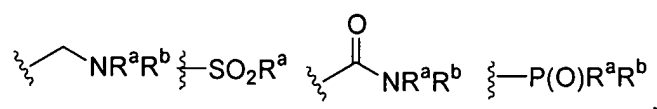
subjecting the compound of Formula (XXXVII) to enantioselective mono-ortho-lithiation using at least one lithiating agent selected from the group consisting of n-butyllithium, sec-butyllithium, and tert-butyllithium, wherein the mono-ortho-lithiation is conducted in the presence of a homochiral tertiary amine, whereby a chiral monolithium compound is obtained; reacting the chiral monolithium compound *in situ* with a dichlorophosphine of the formula  $R^1PCl_2$  followed by reacting with an organometallic reagent of the formula  $R^2Z$ , wherein  $R^1$  and  $R^2$  are different from each other and are independently selected from the group consisting of unsubstituted branched-chain alkyl, unsubstituted straight-chain alkyl, unsubstituted alkoxy, unsubstituted alkylamino, unsubstituted cycloalkyl, unsubstituted cycloalkoxy, unsubstituted cycloalkylamino, unsubstituted carbocyclic aryl, unsubstituted carbocyclic aryloxy, unsubstituted heteroaryl, unsubstituted heteroaryloxy, unsubstituted carbocyclic arylamino, unsubstituted heteroarylamino, substituted branched-chain alkyl, substituted straight-chain alkyl, substituted alkoxy, substituted alkylamino, substituted cycloalkyl, substituted cycloalkoxy, substituted cycloalkylamino, substituted carbocyclic aryl, substituted carbocyclic aryloxy, substituted heteroaryl, substituted heteroaryloxy, substituted carbocyclic arylamino, and substituted heteroarylamino;

wherein Z is Li or MgY, and wherein Y is a halide, to obtain a phosphorus chiral compound having Formula (XXXVIII):



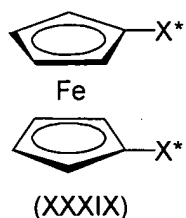
and converting the phosphorus chiral compound having Formula (XXXVIII) to the metallocene-based ligand, wherein the metallocene-based ligand has Formula (I) or Formula (III).

62. (New) The method according to Claim 61, wherein X is selected from the group consisting of:



wherein R<sup>a</sup> and R<sup>b</sup> are independently selected from the group consisting of substituted branched-chain alkyl, substituted straight-chain alkyl, substituted cycloalkyl, substituted carbocyclic aryl, substituted heteroaryl, unsubstituted branched-chain alkyl, unsubstituted straight-chain alkyl, unsubstituted cycloalkyl, unsubstituted carbocyclic aryl, and unsubstituted heteroaryl.

63. (New) A method for preparing a metallocene-based ligand of Claim 44, comprising: providing a compound of the Formula (XXXIX):

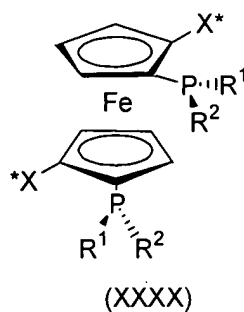


wherein X\* is a chiral directing group;

subjecting the compound of Formula (XXXIX) to bis-ortho-lithiation using at least one lithiating agent selected from the group consisting of n-butyllithium, sec-butyllithium, and tert-butyllithium, whereby a bislithium compound *in situ* with a dichlorophosphine of the formula R<sup>1</sup>PCl<sub>2</sub> followed by reacting with an organometallic reagent of the formula R<sup>2</sup>Z wherein R<sup>1</sup> and R<sup>2</sup> are different from each other and are independently selected from the group consisting of unsubstituted branched-chain alkyl, unsubstituted straight-chain alkyl, unsubstituted alkoxy, unsubstituted alkylamino, unsubstituted cycloalkyl, unsubstituted cycloalkoxy, unsubstituted cycloalkylamino, unsubstituted carbocyclic aryl, unsubstituted carbocyclic aryloxy, unsubstituted heteroaryl, unsubstituted heteroaryloxy, unsubstituted carbocyclic arylamino, unsubstituted

heteroaryl-amino, substituted branched-chain alkyl, substituted straight-chain alkyl, substituted alkoxy, substituted alkyl-amino, substituted cycloalkyl, substituted cycloalkoxy, substituted cycloalkyl-amino, substituted carbocyclic aryl, substituted carbocyclic aryloxy, substituted heteroaryl, substituted heteroaryloxy, substituted carbocyclic aryl-amino, and substituted heteroaryl-amino;

wherein Z is Li or MgY, and wherein Y is a halide, to obtain a phosphorus chiral compound having Formula (XXXX):



and converting the phosphorous chiral compound having Formula (XXXX) to the metallocene-based ligand, wherein the metallocene-based ligand has Formula (II).